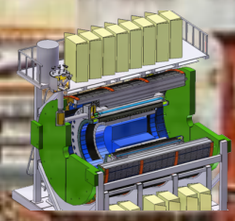
The Future of Hard QGP Probes at RHIC: sPHENIX



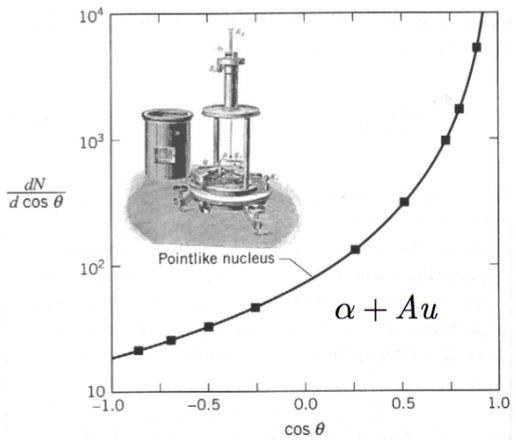
Gunther Roland (MIT), Dave Morrison (BNL)
for the sPHENIX collaboration

The 2015 LONG RANGE PLAN for NUCLEAR SCIENCE

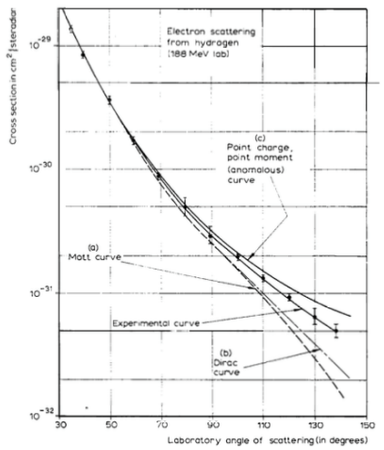
There are two central goals of measurements planned at RHIC, as it completes its scientific mission, and at the LHC: **(1) Probe the inner workings of QGP by resolving its properties at shorter and shorter length scales. The complementarity of the two facilities is essential to this goal, as is a state-of-the-art jet detector at RHIC, called sPHENIX. (2) Map the phase diagram of QCD with experiments planned at RHIC.**

Microscopic structure of matter

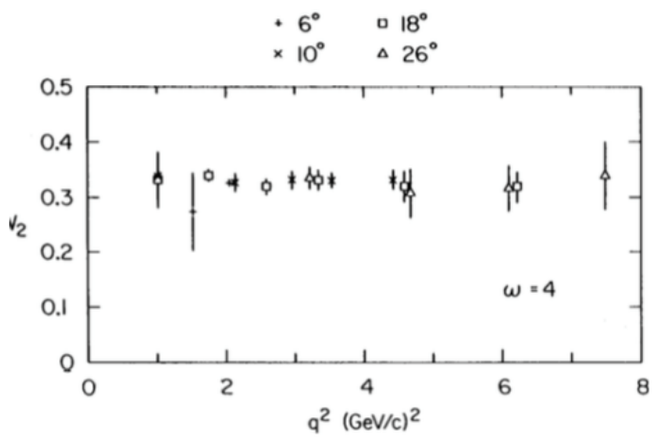
Atoms➔Nuclei

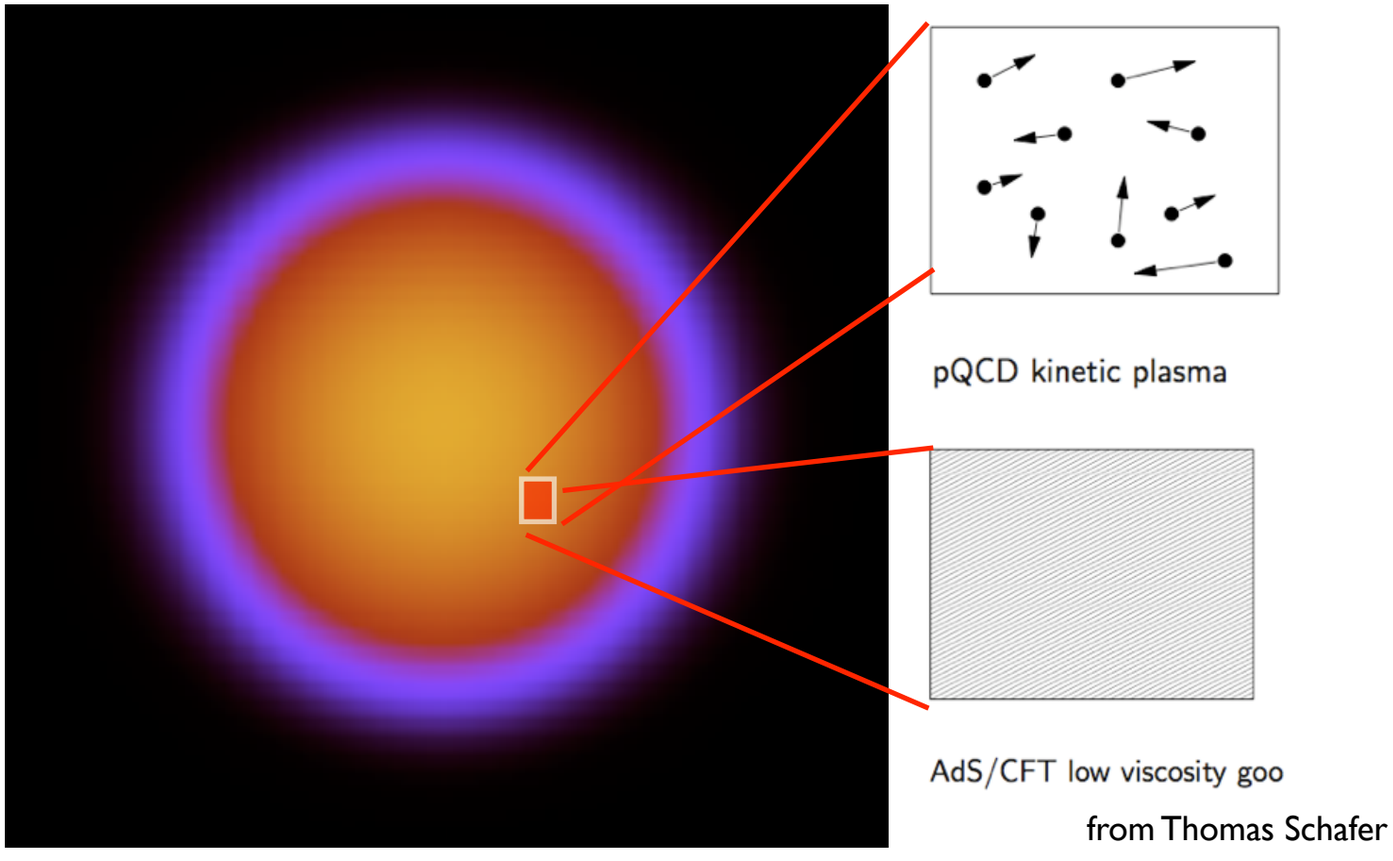


Nuclei➔Nucleons



Nucleons➔Quarks





from Thomas Schafer

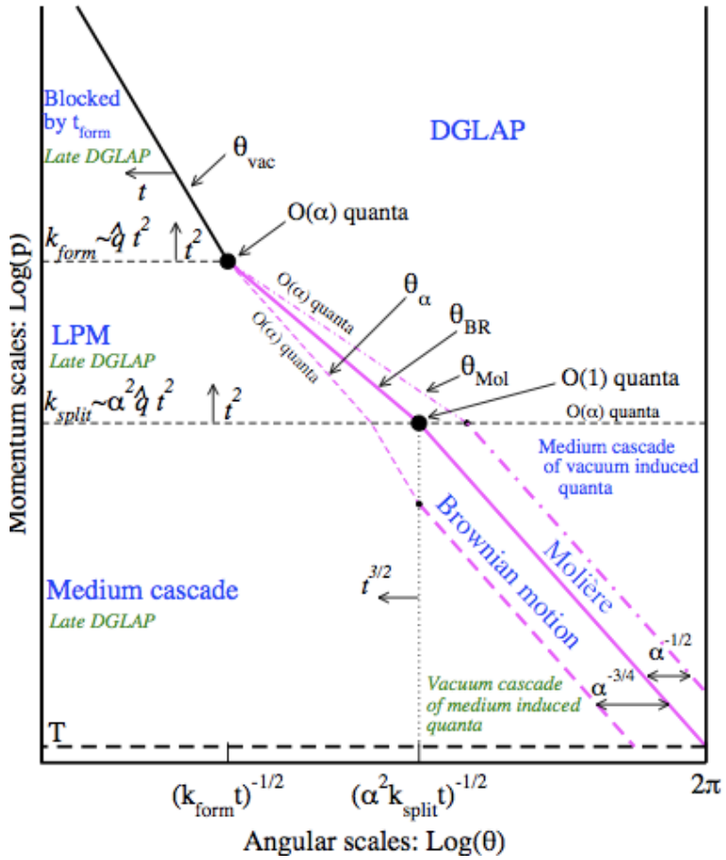
sQGP liquid $\overset{(?)}{\leftrightarrow}$ quasiparticles

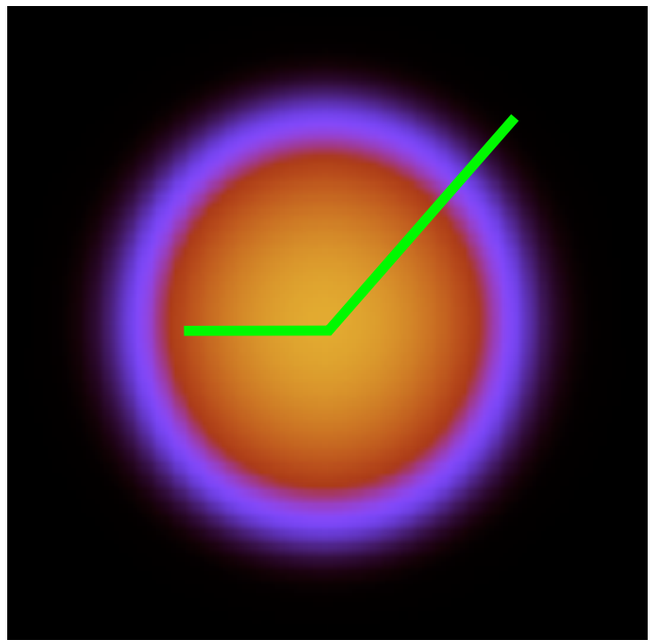
Unavoidable complexity due to strongly interacting nature of QGP probes

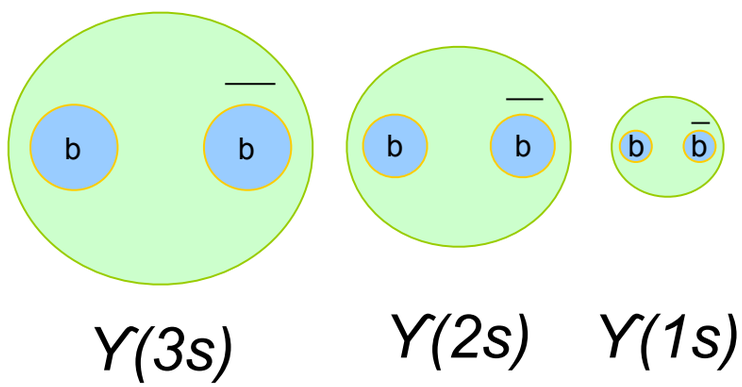
Multi-scale probes of QGP

Three key approaches to study
QGP structure at multiple scales

Jets and jet structure



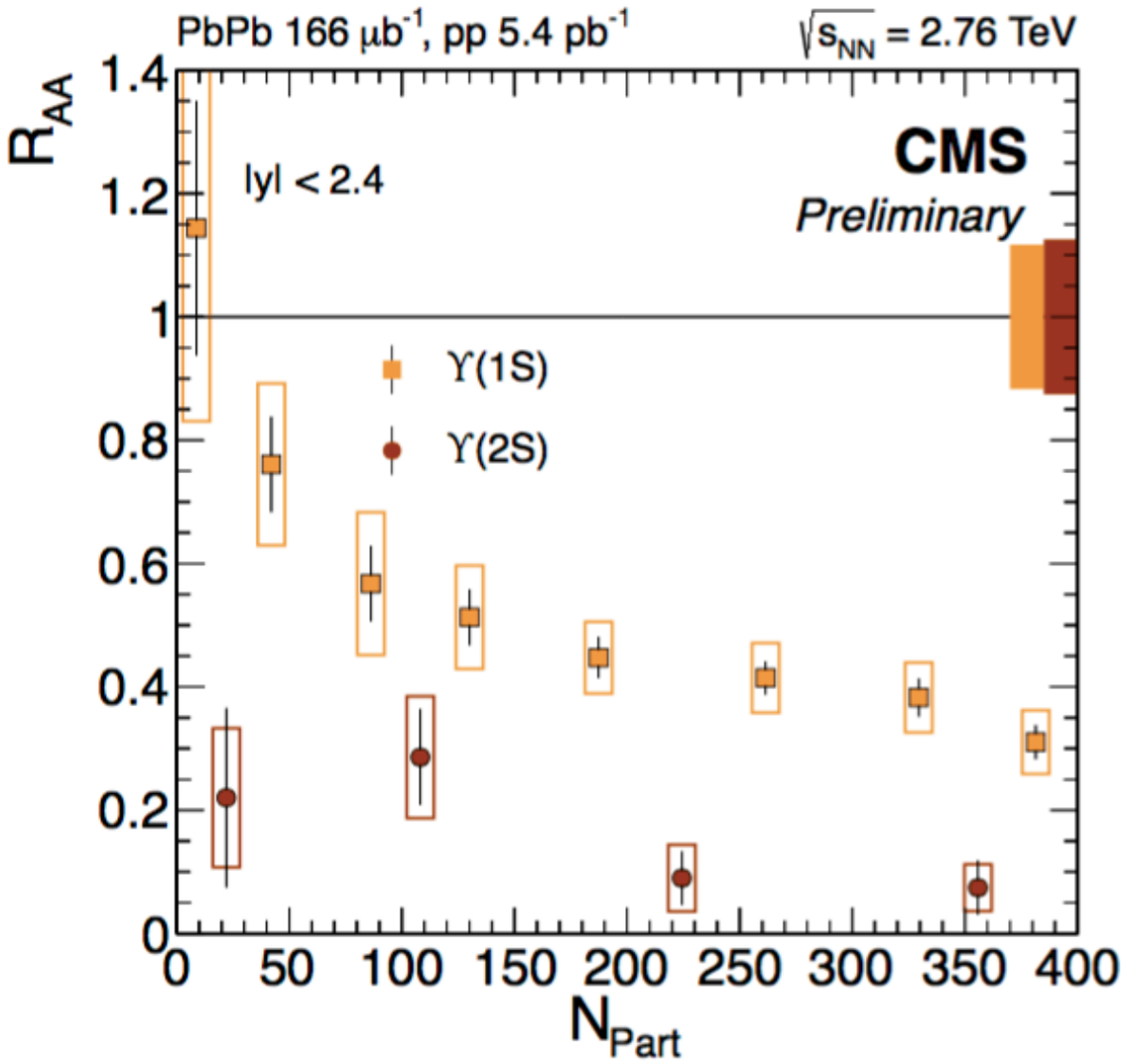




Parton mass/flavor

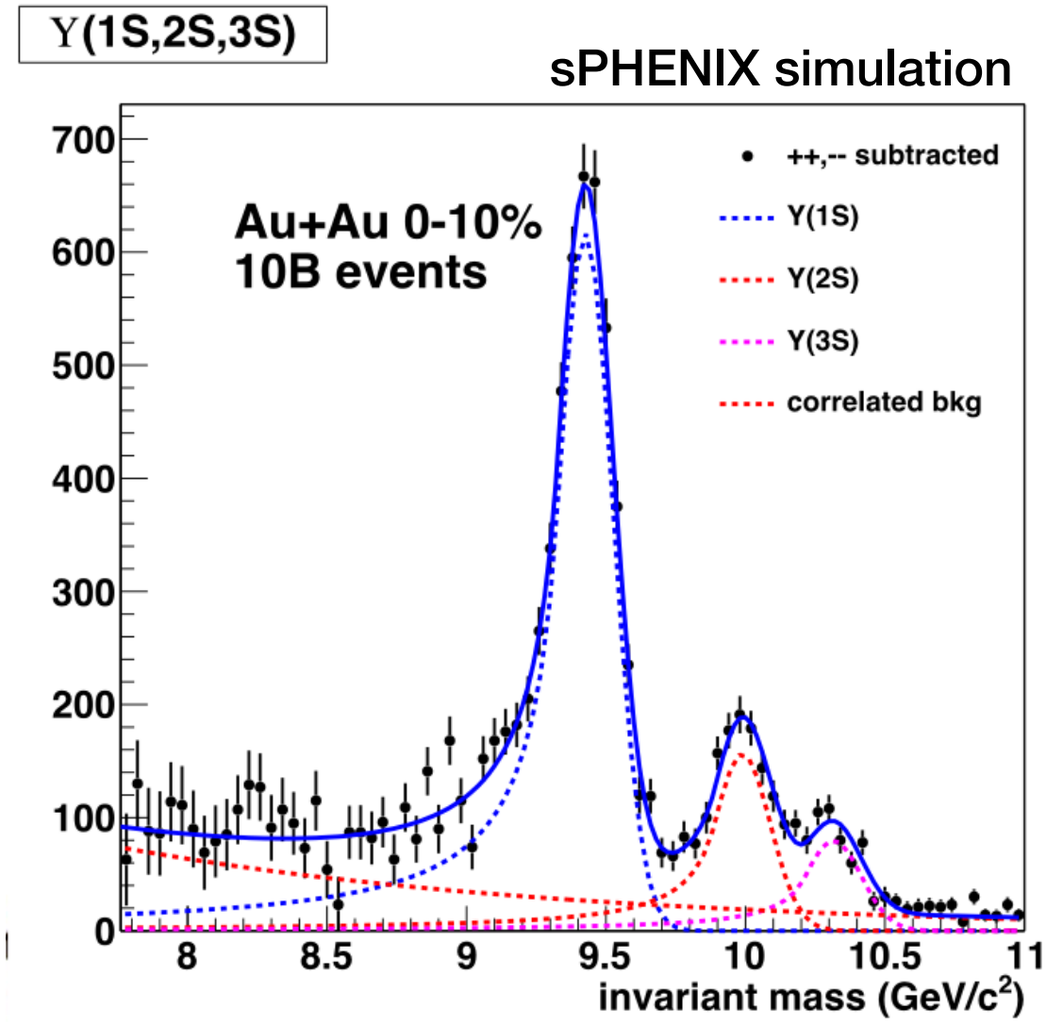
Upsilon spectroscopy

Physics drives detector requirements: Y(ns)



Rapid disappearance of Y(2s), Y(3s) in peripheral events is puzzling ➜

Statistics, statistics, statistics…



Count every Y delivered ➜

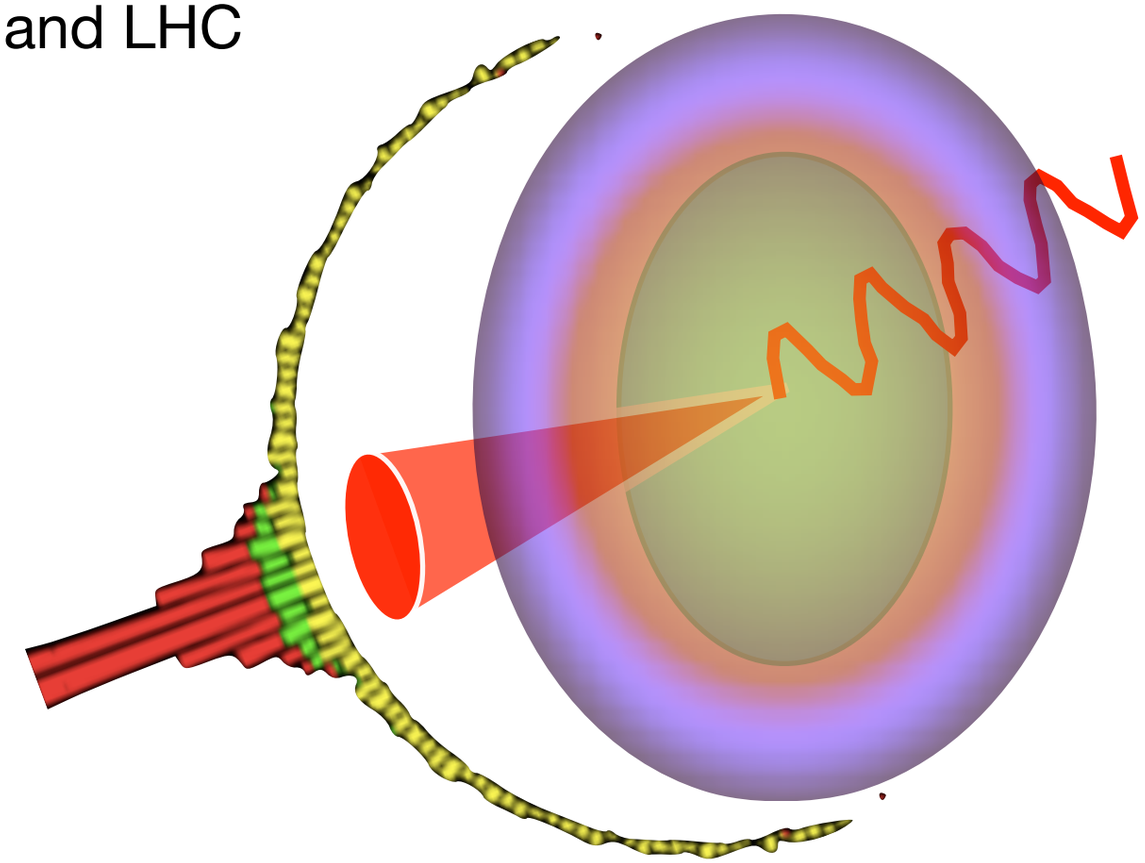
high rate, large acceptance

Make every Y count ➜

excellent momentum resolution

Physics drives detector requirements: Jets and HF

Unified approach to jet physics at RHIC and LHC



Use away- and near-side tags to control initial hard system:

- Parton flavor and mass
- Initial momentum
- Pathlength
- In-medium evolution
- Initial and final state radiation

➜

Photon and HF tagging
HF meson reconstruction
High rate
Control over jet energy scale

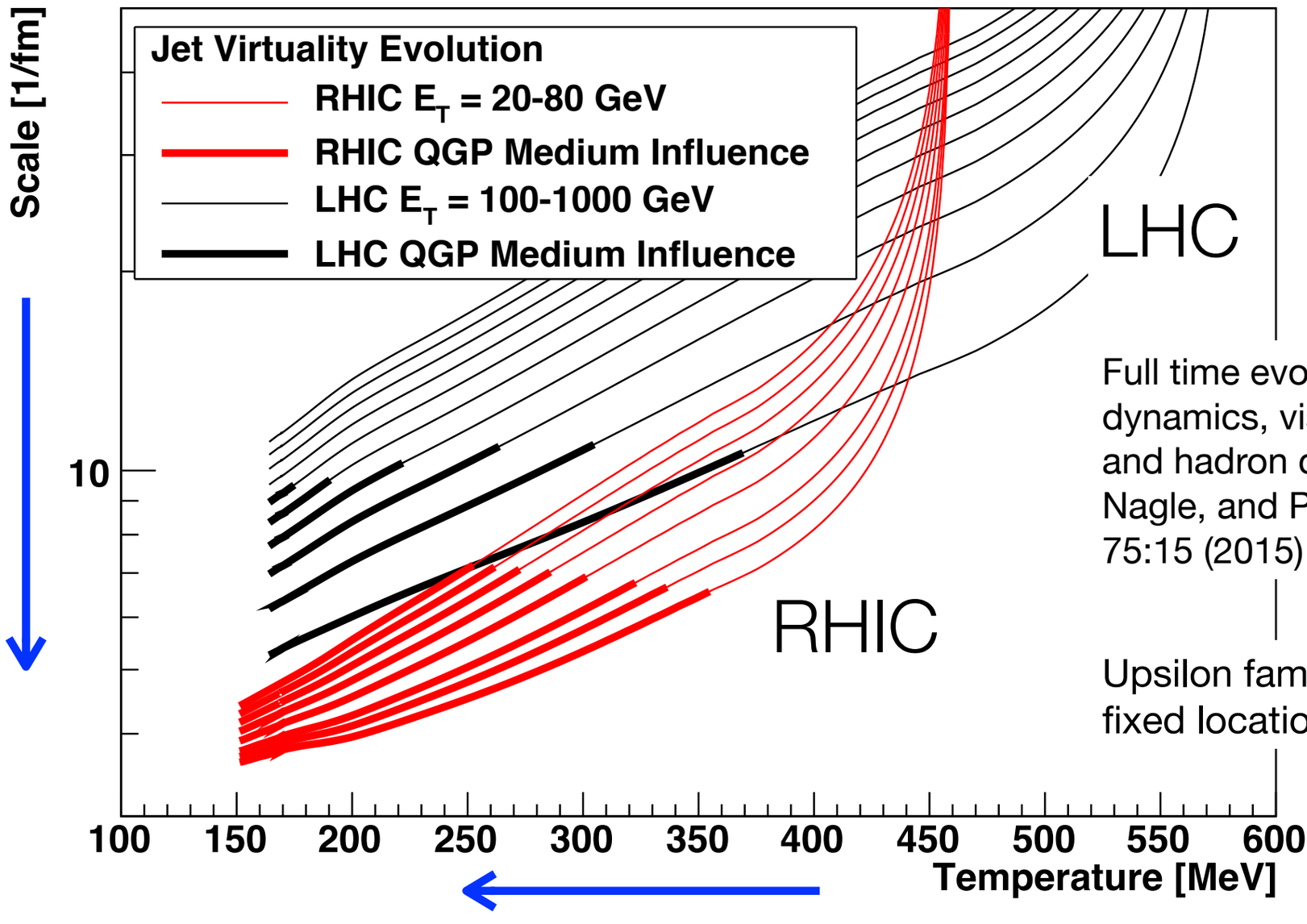
Fully characterize momentum flow near the jet, both "in-cone" and "out-of-cone"➜

Full azimuthal coverage w/ tracking and calorimetry
Large acceptance in p_T and rapidity
High tracking efficiency, low fake rate

TOMOGRAPHY
: a method of producing a three-dimensional image of the internal structures of a solid object by the observation and recording of the differences in the effects on the passage of waves of energy impinging on those structures

Evolving probes in evolving medium: RHIC ⊕ LHC

Initial hard scattered parton virtuality in units of 1/fm as a function of the local temperature of the QGP medium

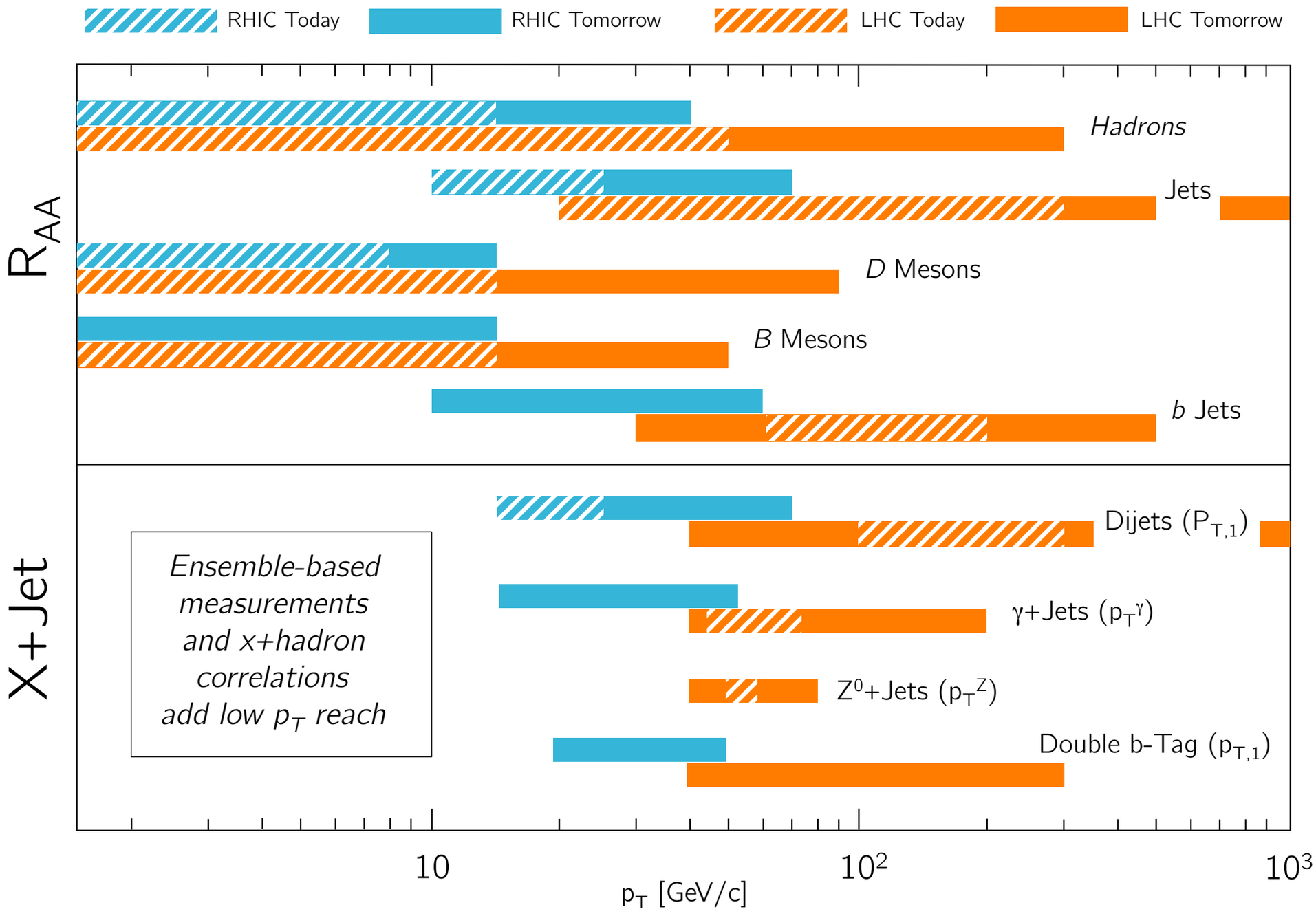


Full time evolution of pre-equilibrium dynamics, viscous hydrodynamics, and hadron cascade M. Habich, J. Nagle, and P. Romatschke, EPJC, 75:15 (2015)

Upsilon family 1S, 2S, 3S establish fixed locations in this space

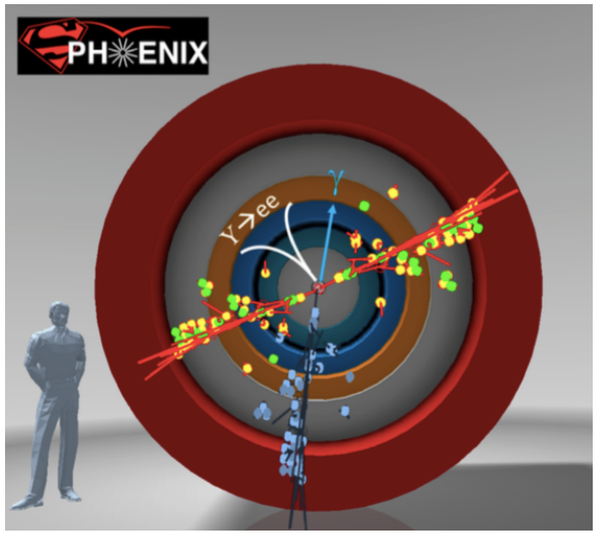
Vacuum virtuality evolution initially, with medium influence becoming significant as virtuality of parton shower and medium become comparable

Physics drives detector requirements: RHIC ⊕ LHC



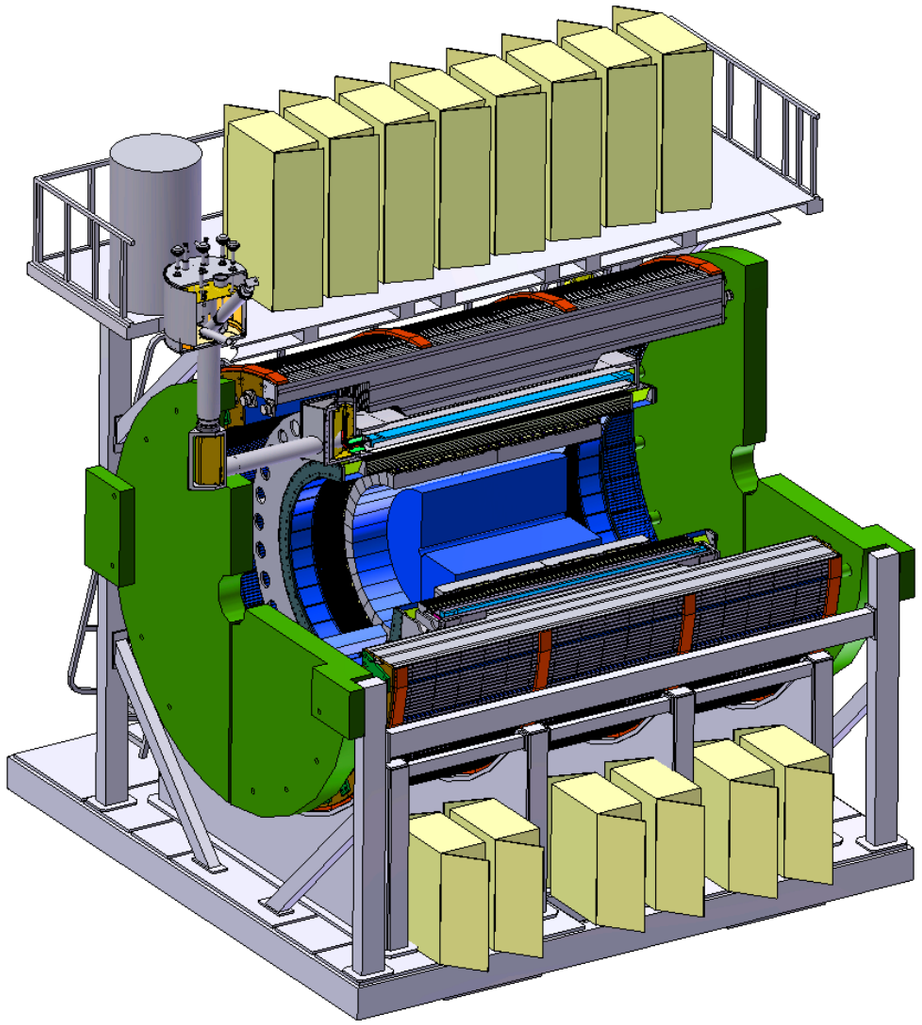
Physics drives detector requirements

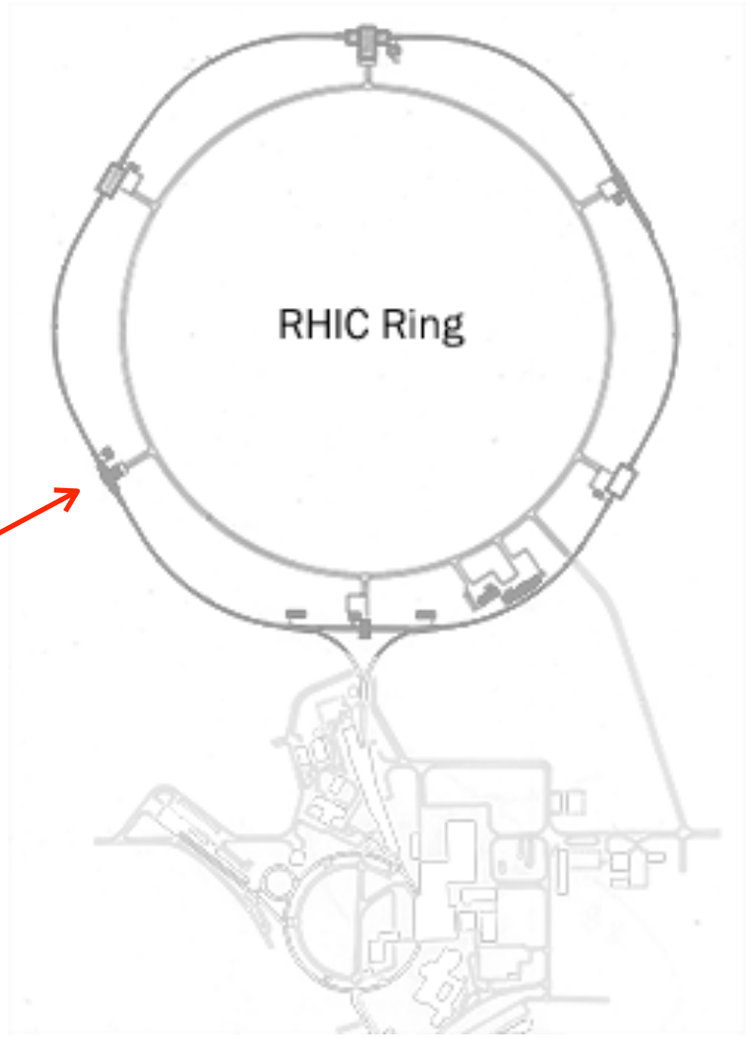
Physics goal	Detector requirement
High statistics for rare probes	Accept/sample full delivered luminosity Full azimuthal and large rapidity acceptance
Precision Upsilon spectroscopy	Hadron rejection > 99% with good $e^{+/-}$ acceptance Mass resolution 1% @ m_Υ
High jet efficiency and resolution	Full hadron and EM calorimetry Tracking from low to high pT
Control over parton mass	**Precision vertexing for heavy flavor ID**
Control over initial parton p_T	Large acceptance, high resolution photon ID
Full characterization of jet final state	High efficiency tracking for $0.2 < p_T < 40$GeV



State-of-the-art jet detector at RHIC

sPHENIX: A high-rate capable detector at RHIC IP8, built around the former BaBar 1.5 T superconducting solenoid, with full electromagnetic and hadronic calorimetry and precision tracking and vertexing, with a core physics program focused on light and heavy-flavor jets, direct photons, Upsilons and their correlations in p+p, p+A, and A+A to study the underlying dynamics of the QGP – physics delivered by 22 weeks of Au+Au, 10 weeks each of p+p and p+A (@ 200 GeV).





State-of-the-art jet detector at RHIC: sPHENIX

John Harris as acting IB chair, institutions were asked to indicate their potential interest in the collaboration, leading to a first collaboration meeting at Rutgers in December 2015

Inaugural sPHENIX collaboration meeting: Rutgers, Dec 2015

Rosi Reed (Lehigh)

Sevil Salur (Rutgers)

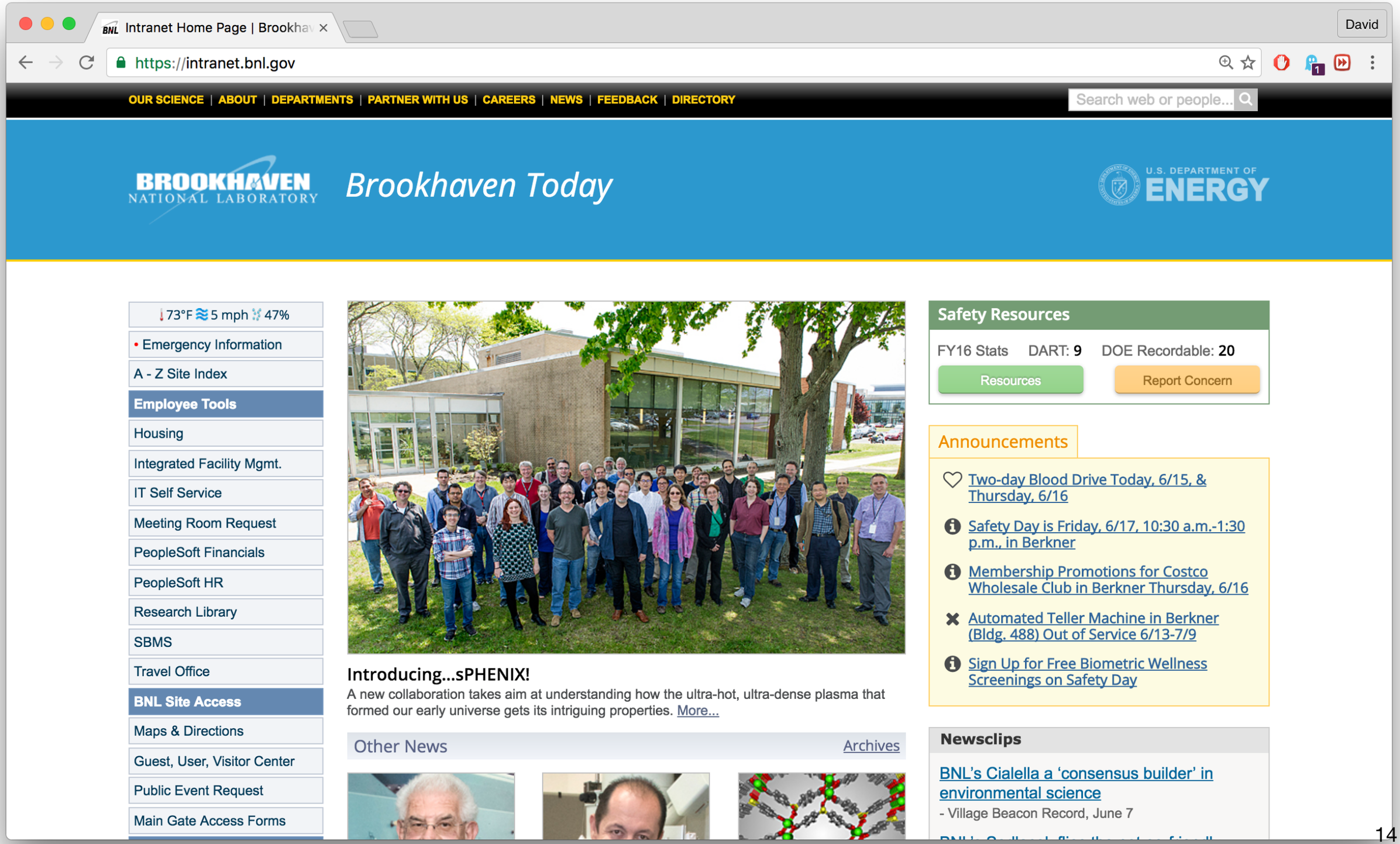
Hosts

2015 sPHENIX census

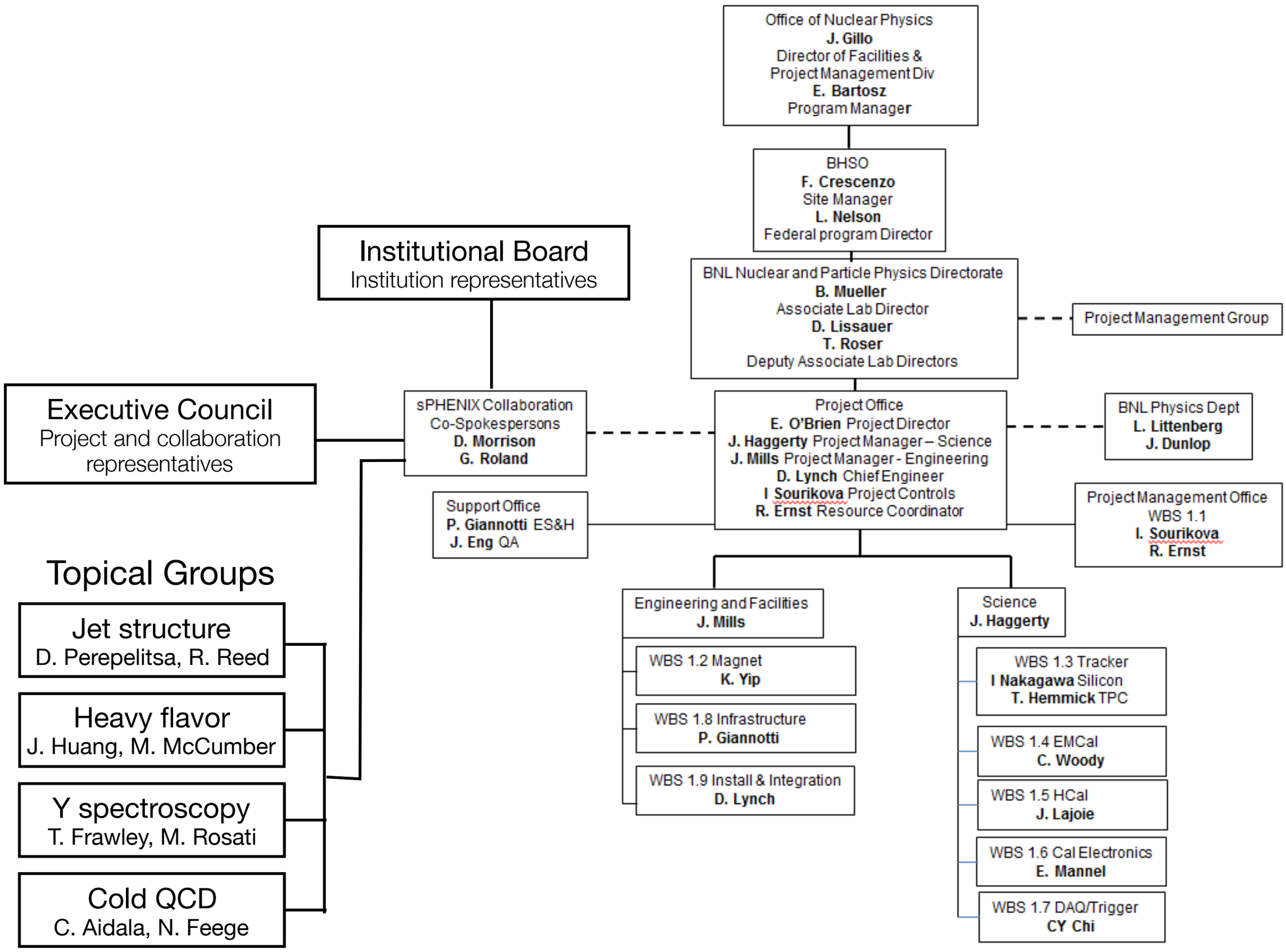
57 institutions signed up: Abilene Christian, Augustana College, Banaras Hindu University (India), Baruch College, CUNY, BNL and BNL (PHENIX), UC-Davis, UCLA, UCR, Chonbuk National University (South Korea), Colorado, Columbia, Joint Czech Group (Charles University): Prague Czech Technical University, Prague Institute of Physics, Czech Academy of Sciences – Prague; University of Debrecen, Florida State, Georgia State, Howard University, Houston, sPHENIX (Hungary), Illinois – U.C., Institute of Nuclear Research, Russian Academy of Sciences, Moscow, Iowa State, University of Jammu (India), JAEA (Japan Atomic Energy Agency), Korea University, National Research Centre "Kurchatov Institute", Lehigh, LLNL, LANL, Maryland, MIT, Michigan, National Research Nuclear University (Moscow Engineering Physics Institute), Muhlenberg College, Nara Women's University (Japan), New Mexico State, University of New Mexico, ORNL, Ohio University, Insititut de Physique Nucléaire d'Orsay, Petersburg Nuclear Physics Institute (National Research Centre "Kurchatev Institute"), IHEP (Protvino), RIKEN/RBRC, Rikkyo University, Rutgers, Stony Brook, Saint-Petersburg Polytechnic University, Tennessee - Knoxville, Texas - Austin, Tokyo Institute of Technology (Tokyo Tech, TITech), University of Tokyo (Center for Nuclear Study), Institute of Physics - University of Tsukuba, Universidad Técnica Federico Santa María - Valparaíso (Chile), Vanderbilt, Wayne State, Weizmann Institute, Yale, Yonsei University (Korea).

Many international and non-PHENIX institutions
Continued strong role of RIKEN/RBRC

Second sPHENIX collaboration meeting: BNL, May 2016



Collaboration and project organization



Connection to spin physics and EIC community

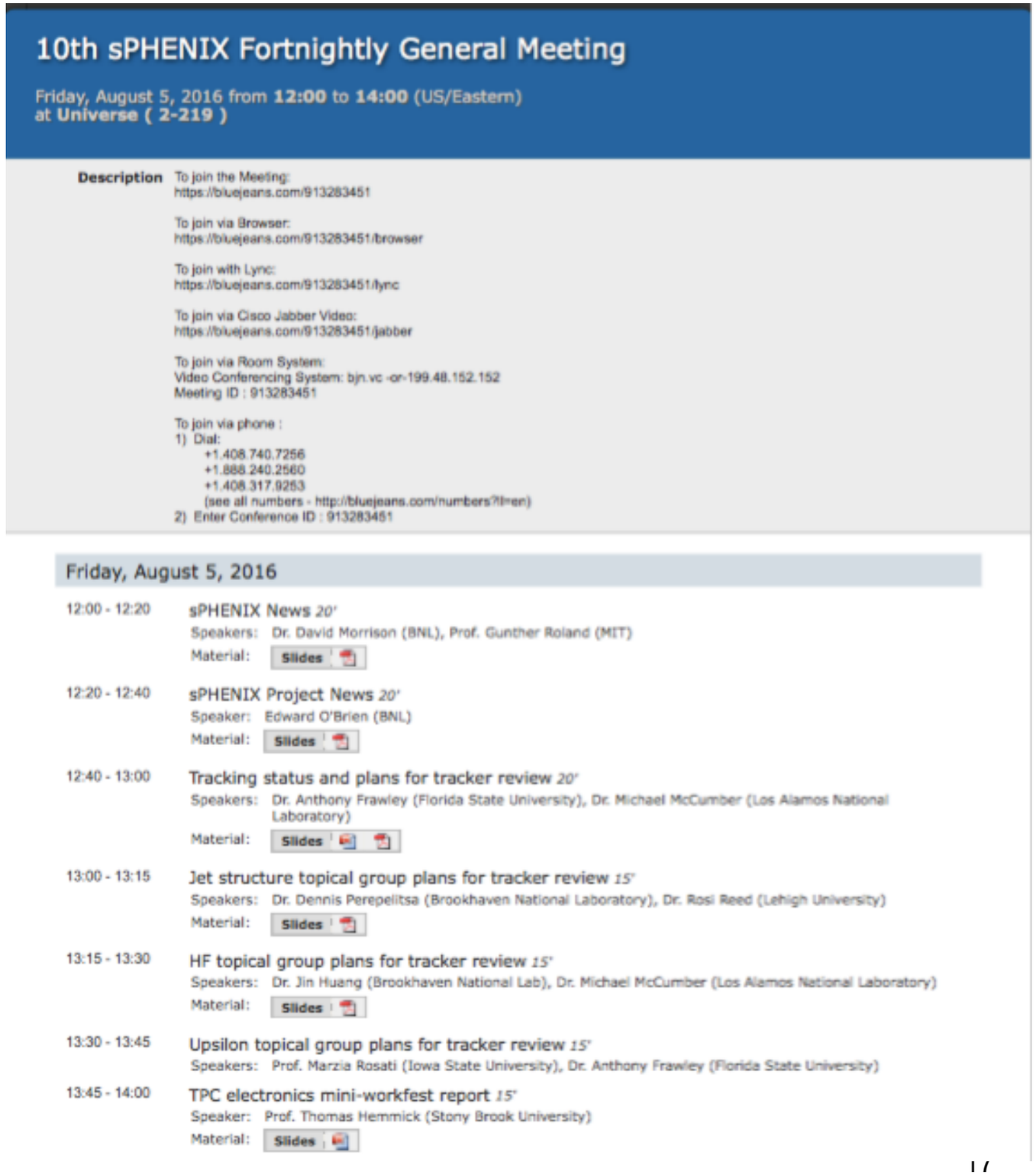
- Collaboration has large community interested in cold QCD/spin physics measurements
- Connection to generic EIC R&D (e.g. TPC, EMCal)
- Natural convergence of sPHENIX design choices (e.g., Magnet, MAPS vertex tracker, TPC outer tracker, EMCal) with mid-rapidity instrumentation of day-1 EIC detector
- Focus is on a world-class jet/Y detector at RHIC, while keeping efficient path towards EIC open

Close connection of collaboration and project: Fortnightly General Meetings

Fortnightly meetings to discuss project and collaboration news:

- Reports from collaboration and project management
- Reports from detector and physics/ simulations efforts

Open to all collaborators; good attendance



10th sPHENIX Fortnightly General Meeting

Friday, August 5, 2016 from **12:00** to **14:00** (US/Eastern)
at **Universe (2-219)**

Description
To join the Meeting:
https://bluejeans.com/913283451

To join via Browser:
https://bluejeans.com/913283451/browser

To join with Lync:
https://bluejeans.com/913283451/lync

To join via Cisco Jabber Video:
https://bluejeans.com/913283451/jabber

To join via Room System:
Video Conferencing System: bjn.vc -or- 199.48.152.152
Meeting ID : 913283451

To join via phone :
1) Dial:
+1.408.740.7256
+1.888.240.2560
+1.408.317.9253
(see all numbers - http://bluejeans.com/numbers?tl=en)
2) Enter Conference ID : 913283451

Friday, August 5, 2016

12:00 - 12:20 sPHENIX News *20'*
Speakers: Dr. David Morrison (BNL), Prof. Gunther Roland (MIT)
Material: Slides

12:20 - 12:40 sPHENIX Project News *20'*
Speaker: Edward O'Brien (BNL)
Material: Slides

12:40 - 13:00 Tracking status and plans for tracker review *20'*
Speakers: Dr. Anthony Frawley (Florida State University), Dr. Michael McCumber (Los Alamos National Laboratory)
Material: Slides

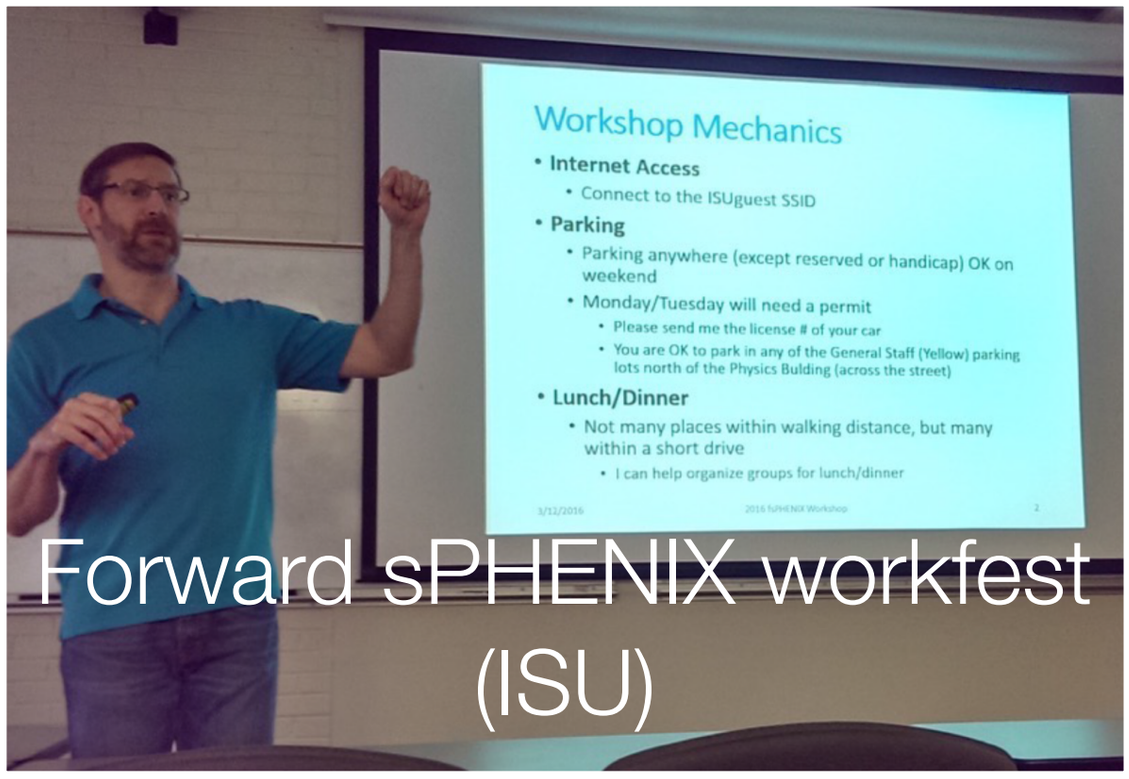
13:00 - 13:15 Jet structure topical group plans for tracker review *15'*
Speakers: Dr. Dennis Perepelitsa (Brookhaven National Laboratory), Dr. Rosi Reed (Lehigh University)
Material: Slides

13:15 - 13:30 HF topical group plans for tracker review *15'*
Speakers: Dr. Jin Huang (Brookhaven National Lab), Dr. Michael McCumber (Los Alamos National Laboratory)
Material: Slides

13:30 - 13:45 Upsilon topical group plans for tracker review *15'*
Speakers: Prof. Marzia Rosati (Iowa State University), Dr. Anthony Frawley (Florida State University)

13:45 - 14:00 TPC electronics mini-workfest report *15'*
Speaker: Prof. Thomas Hemmick (Stony Brook University)
Material: Slides

Close connection of collaboration and project: PHENIX-style workfests



- Continues practice that was very productive in developing sPHENIX proposals
- Invite outside experts when appropriate – e.g., discussion with ALICE & STAR experts on space charge distortion in TPC
- Recent activities: two-day EMCal workfest in August, two-day test beam paper writing workshop, discussion with ALICE to gauge needs of sPHENIX TPC readout

Outlook

- sPHENIX scientific collaboration in full swing working towards 2022 start of physics
- Ongoing efforts to strengthen collaboration:
  - discussions with additional (strong) groups about joining sPHENIX
  - ongoing effort to strengthen workforce from member institutions
  - discussion on hardware collaboration (e.g. w/ ALICE reg. MAPS) with non-member groups
  - Having CD-0 would be **very helpful** in such discussions
- Continued effort to sharpen the sPHENIX science case
- Collaboration is committed to building a world-class experiment with the capabilities needed to deliver the full suite of sPHENIX physics